TECHNOLOGIES FOR ICY BODIES' ACCESS, OPERATIONS AND SCIENCE

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Introduction: Recent events in planetary exploration have profoundly changed the way both space scientists and the public regard the solar system and our place in it. These events include the Galileo data suggesting subsurface oceans in the Jovian system (1), ever stronger suggestions of near-surface water on Mars, as well as the complex structure observed for the Mars polar caps. And, of course, interest in icy cometary bodies is as old as humankind itself. Finally, the Mars north polar cap may conceivably cover and protect an ancient ocean floor, an obvious candidate ancient or extant habitat.

In short, our interest in the search for life embraced early on the search for liquid water, and that has led us to an additional appreciation for water ice as both a commonplace partner with liquid water and as an issue to be addressed in the exploration of a host of interesting sites. In general, the spectrum of specialized technology for space exploration has not yet been broadened to include the requirements brought about by exploration of icy sites. We argue that technologies for access, operations, and science in icy solar-system sites must be examined and their prioritized development initiated in order to successfully plan missions to these compelling sites over the next two decades.

Ice and Water: While our Earth experience leads us to focus on bulk surface water as the expected form, it is clear that it is rare; new results even suggest that in Earth's deep past there were episodes of a fully ice-covered or "Snowball" Earth. Liquid water is found in at least three other situations: Beneath an ice roof, interstitially in warm ice, and as ground-water (including interstitially in ground ice). Interstitial liquid water (2) is especially interesting. During ice growth this liquid is at saturation, and consequently not particularly attractive as microbial habitat, but it is a useful concentrator of material held in an ice mass; that is, it is a likely place to look for nutrients and therefore exobiological lifeforms may have inhabited the neighborhood.

Access: Exploration of many sites of present day or ancient liquid water involve moving through, and analyzing composition of, water ice. The ice can be present in significant amount; on Europa. Stevenson (1) has pointed out that an ice cover thinner (or even thicker) than 30 km is energetically unlikely. Even on Mars the polar cap thickness is several kilometers. Other ice sites are even less friendly; we note that comets are thought to be balls of violently sublimating, dirty ice. Clearly, access to icy surface and subsurface sites involve significant technology development as well as insight into the nature of the place.

Operations: Once we have achieved access to a site, we want to perform operations: move about, determine our location, communicate and exercise control, take scientific data, and look after the health of the exploration vehicle. On Europa, each of these simple needs is a significant challenge. It is interesting to note that scientific and operational autonomy are debated as to need for solar system exploration in general, but they are essential to a trip to the Europa Ocean, because of all that ice among other reasons.

Planetary Protection: Working without contamination is obviously essential in all life-detection explorations. In an icy environment, this requirement will profoundly impact vehicle fabrication.

Science: Taking data in or on an ice cap will bring special constraints to in-situ science. The issues for consideration include pressure, structure and chemistry in the deep subsurface, radiation on the surface, documentation of context and sample handing.

Testing Needs and Opportunities: Development of technologies for planetary ice explorations require testing to an extreme degree, especially for devices under consideration for deployment to the Outer Planets.

A Cryofacility, collaborative among technology developers and scientists, is a desired testbed tool to enable technology developers to test concepts, validate processes and verify performance parameters. A Cryofacility would provide resources to develop multivariable ices in density, contaminants, and temperature. This would assist in designing insitu instrument robustness, sample handling and return, and instrument validation and verification. Currently to date, this facility does not exist, and without it, mission planning to these remote sites will be at an impasse.

At the same time, ice on Earth can supply excellent sites for this testing, and, in many cases, the technology being developed will have application in Earth science such that the testing situations involve interesting Earth science sites. We note an interesting example, that of the study of subglacial lakes, that has recently become an Earth science priority (3) and requires many technologies of planetary ice missions.

References:

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